



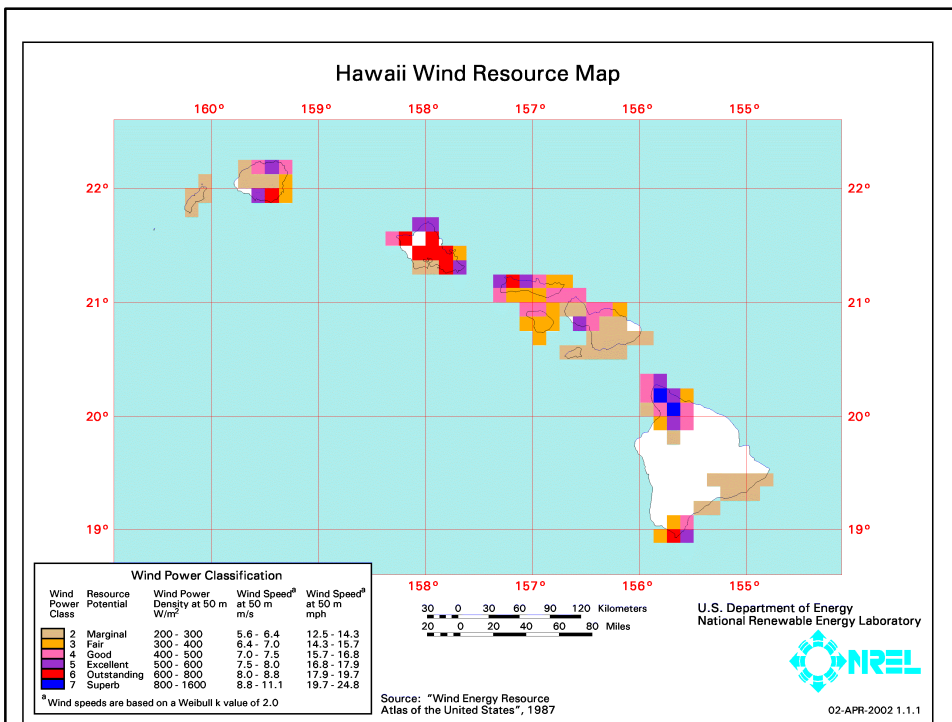
Hawaii Wind Mapping and Validation Project

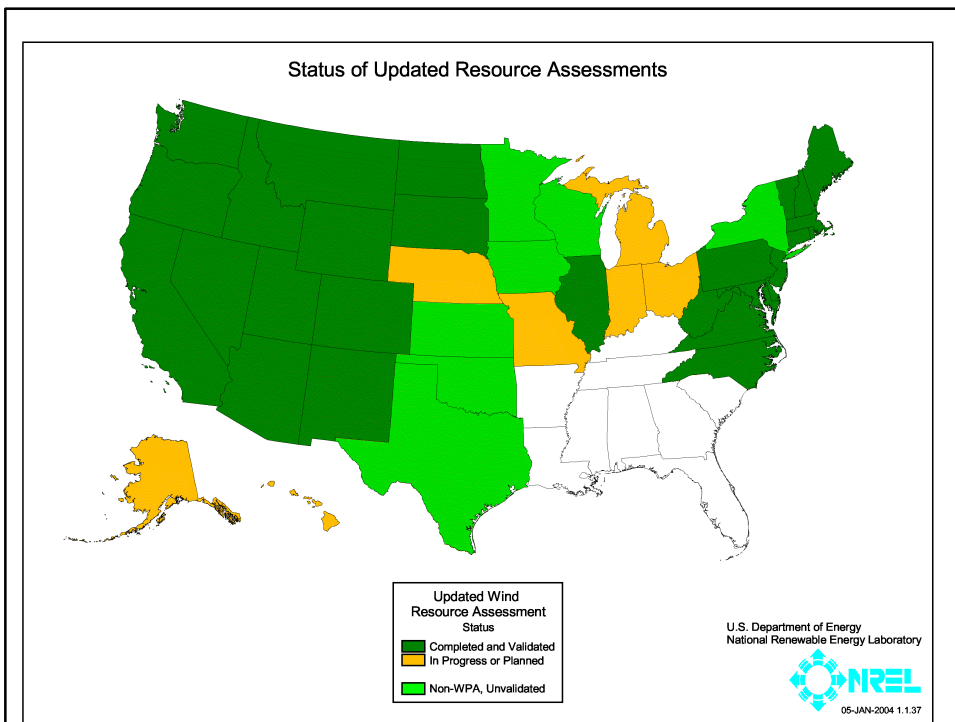
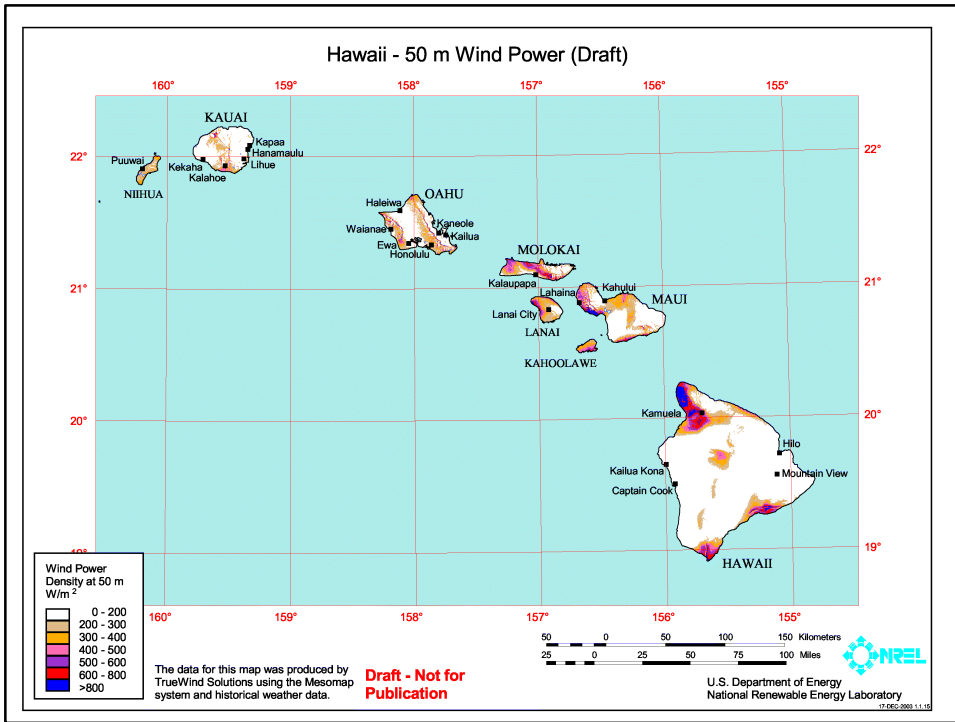
Dennis Elliott

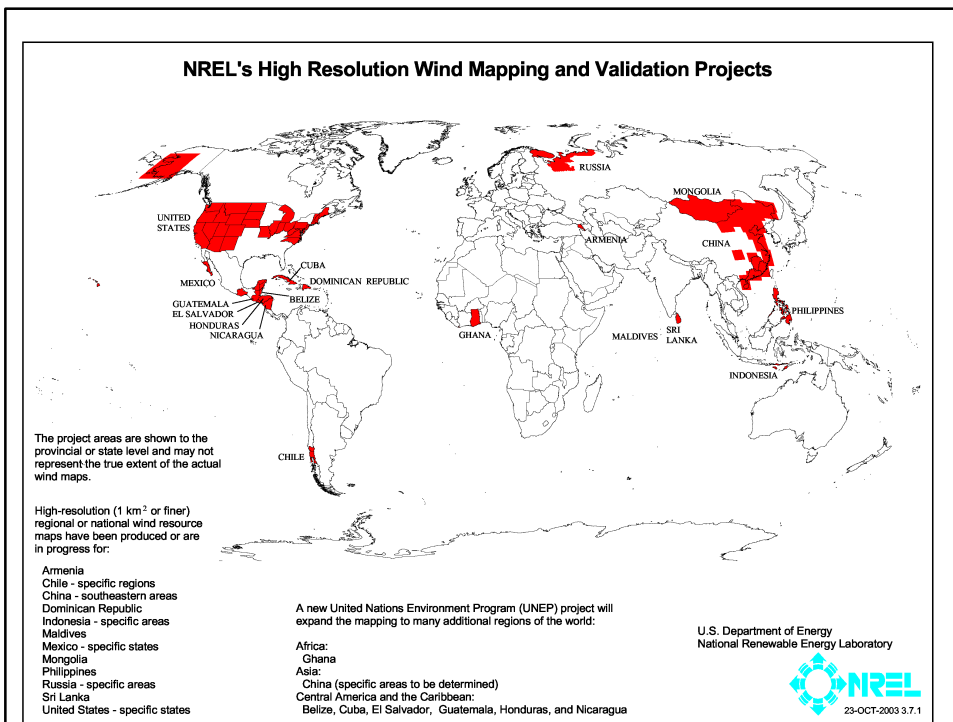
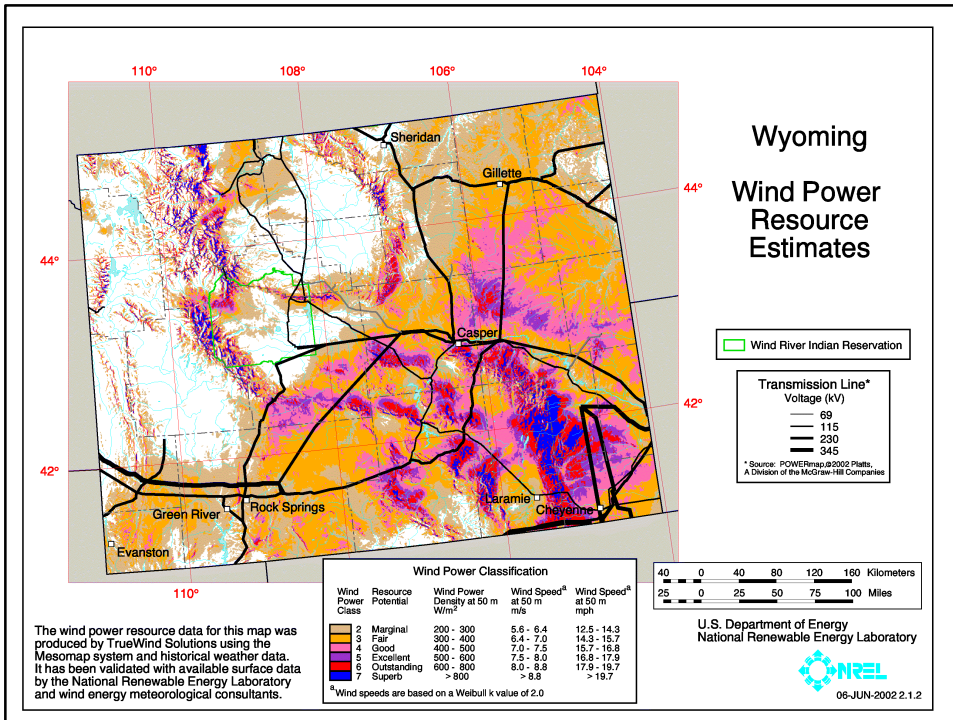
dennis_elliott@nrel.gov, (303) 384-6935

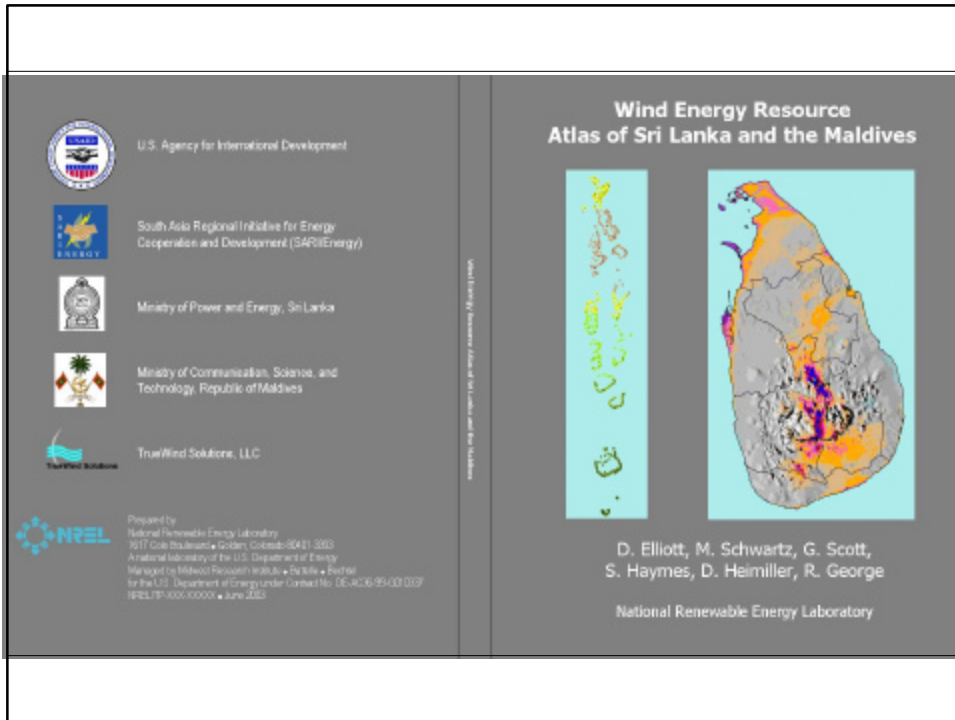
National Renewable Energy Laboratory
Golden, CO

Hawaii Wind Working Group Meeting
Honolulu, Hawaii
January 6, 2004







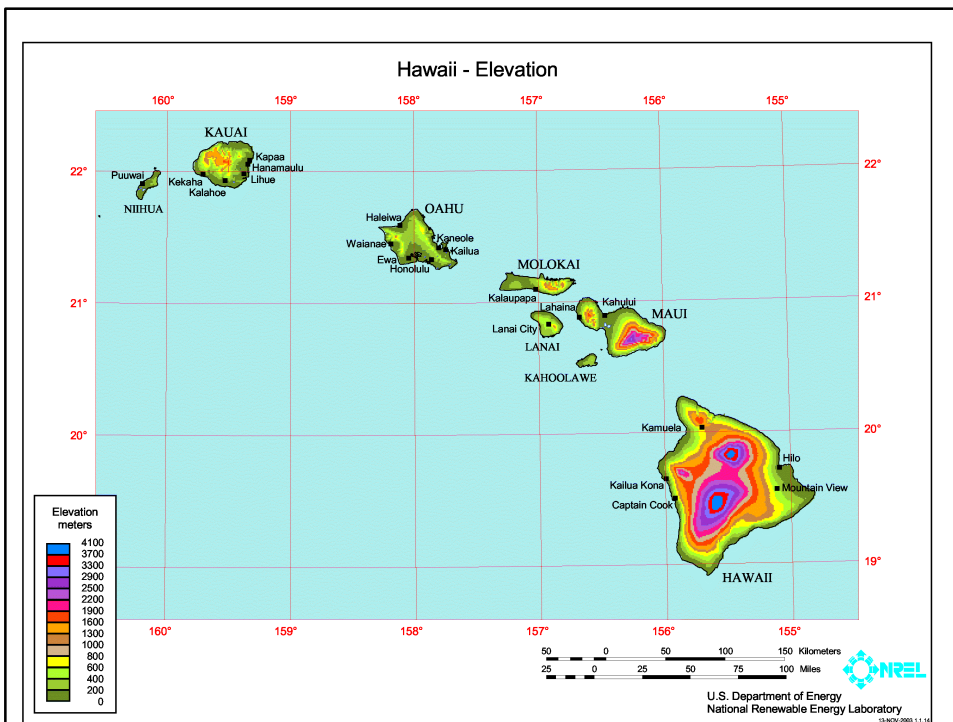


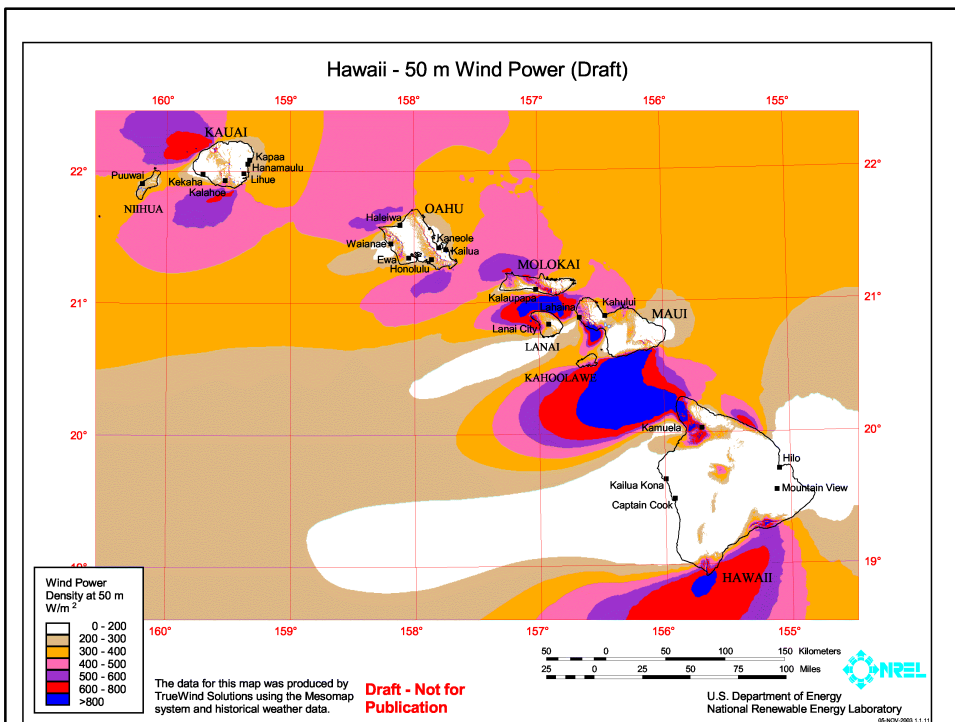
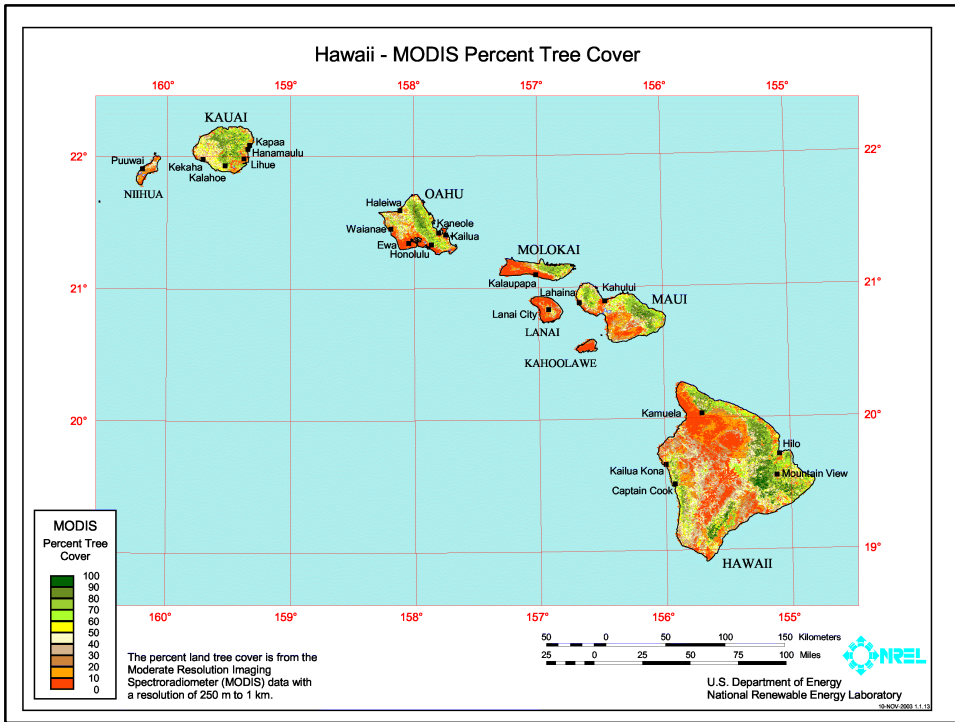
High-Resolution Wind Mapping Approach

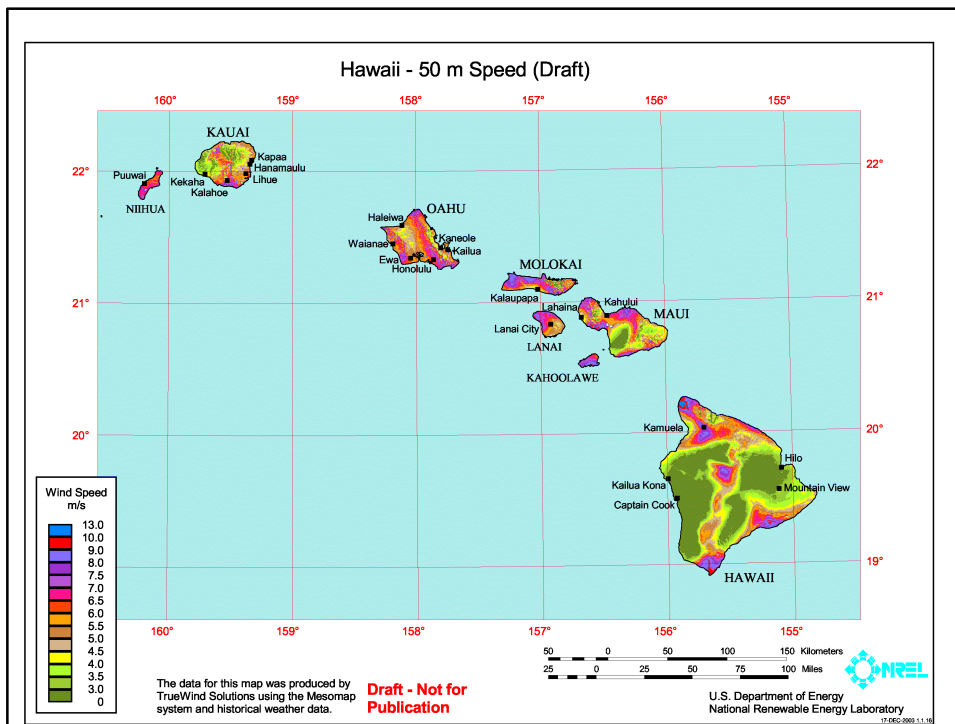
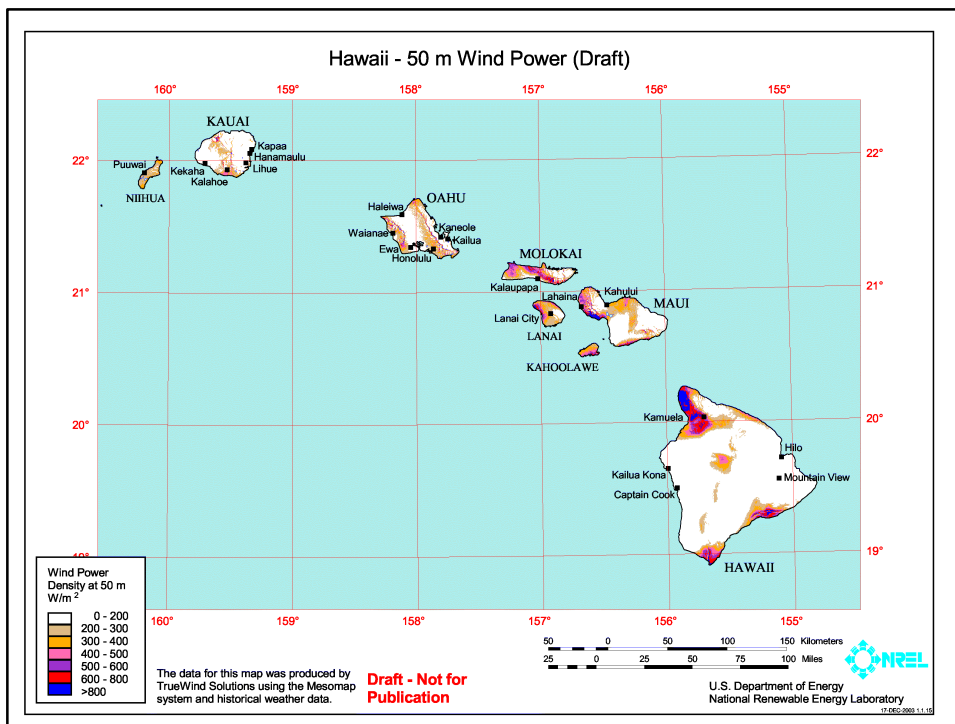
- Produces 200 m resolution wind power maps
- TrueWind Solutions (TWS) uses a numerical weather model with climatic data and wind flow model to produce the preliminary map
- Does not depend on high-quality surface wind data
- Maps designed for regional wind mapping and not micro-siting
- Preliminary maps are validated
 - NREL and meteorological consultants validate TWS produced maps
- TWS adjusts preliminary maps based on validation results and final maps are released

Logic of Numerical Mapping Method

- Model Design and Outputs
 - MesoMap - created by TrueWind Solutions (TWS)
 - A numerical weather model (MASS) coupled to a wind flow model (WindMap) and global weather, topographical, and land cover data
 - NCEP/NCAR Reanalysis (200-km grid) - most important global weather input for MASS
 - MASS simulates weather conditions (incl. winds) over 365 days selected from a 15-year period
 - Hawaii, MASS at 1.2 - 2 km and WindMap to 0.2 km
 - Model output grids provided to NREL for review and validation









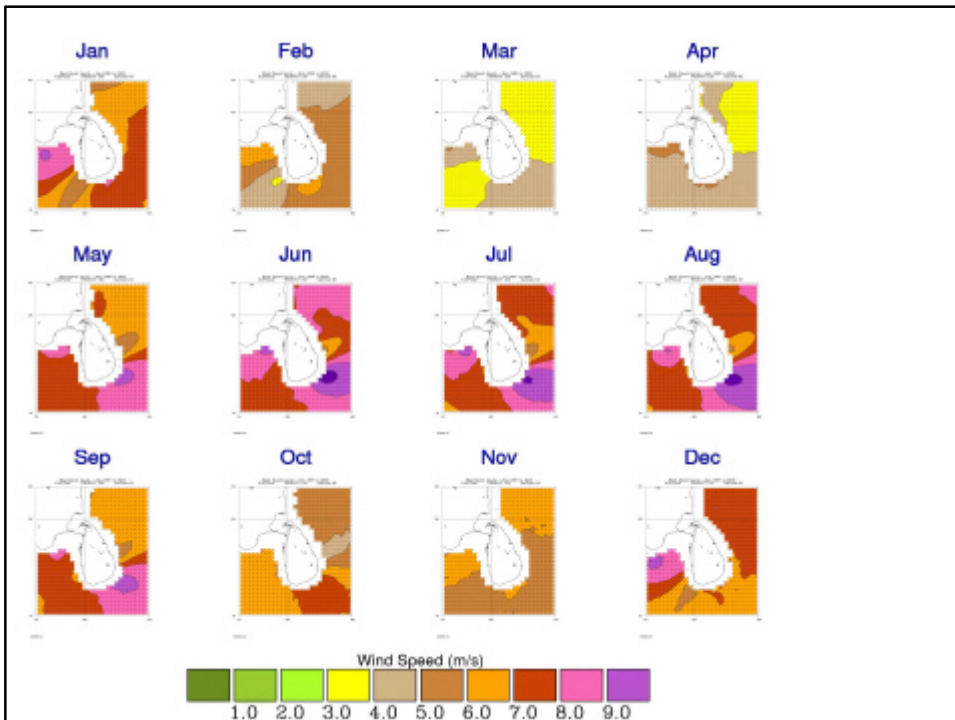
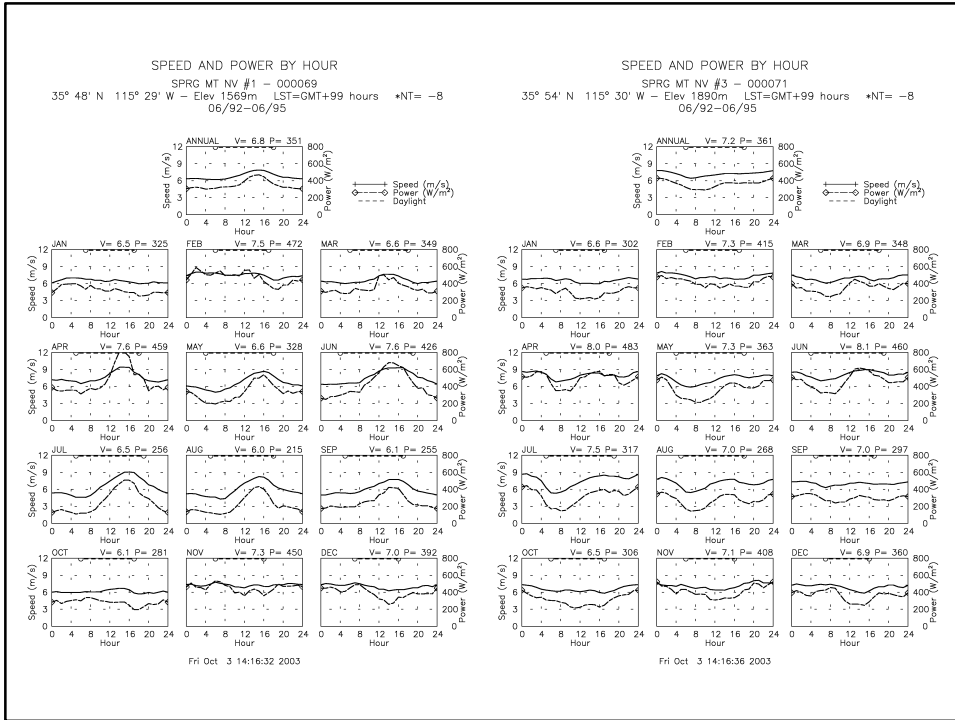
Validation Process

- NREL and validation consultants complete a spreadsheet used in the validation process
 - Each measurement location
 - Site coordinates and elevation
 - Measurement heights and period of record
 - Measured speed and power
 - Adjusted speed and power to map height
 - Map estimates for speed and power
 - Qualitative comments
- NREL & TWS review validation results
- TWS adjusts preliminary maps based on quantitative and qualitative inputs



Major Global Data Sets used by NREL for Wind Resource Assessment

Data Set	Type of Information	Source	Period of Record
Surface Station Data	Surface observations at 20000 stations	NOAA/NCDC	1973-2002
Upper Air Station Data	Rawinsonde and pibal observations at 1800 stations	NCAR	1973-2002
Satellite-derived Ocean Wind Data	10-m ocean wind speeds gridded to 0.25 deg	NASA/JPL	1988-2002
Marine Climatic Atlas of the World	Gridded (1.0 deg) statistics of historical ship wind observations	NOAA/NCDC	1854-1969
Reanalysis Upper Air Data	Model-derived gridded (~200km) upper air data	NCAR	1958-2001
Global Upper Air Climatic Atlas	Model-derived gridded (2.5 deg) upper air statistics	NOAA/NCDC	1980-1991
Digital Geographic Data	Political, hydrography, etc.	ESRI	
Digital Terrain Data	Elevation – 90m - 1 km resolution	USGS/EROS	
Digital Land Cover Data	Land use/cover and tree cover density – 500 m - 1 km resolution	NASA/USGS	





Example of Data Sets: Nevada Validation

- Over 60 measurement stations used for validation
 - 22 GTS (17 Airport, 5 Non-Airport)
 - 14 Kenetech
 - 13 RAWs (U.S Forest Service and BLM)
 - 4 Air Resources Laboratory – SORD
 - 4 Oregon State University
 - 2 Anemometer Loan Program – Indian Reservations
 - 2 Other
 - 8 Proprietary

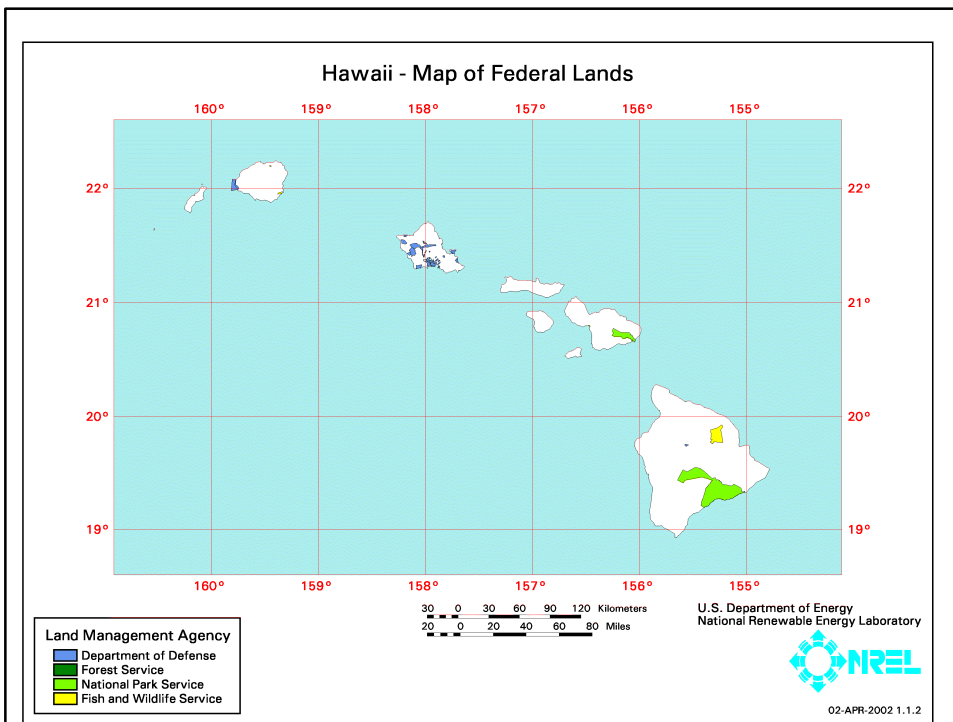


Quantifying Available Windy Lands and Electric Potential by DOE/NREL (2003)

- Class 4 and higher resource areas (good-to-excellent for utility-scale applications) used as base for available windy lands
- Environmental Exclusions – data from State sources?
- Land-use Exclusions – data from State sources?
- Other Factors

Environmental Exclusions

- 100% Exclusions
 - National Park Service, Fish and Wildlife Service
 - Wildlife, Wilderness, and Recreation Areas on federal land of any designation (predominately Forest Service and BLM lands)
 - State and other environmental lands (State GAP data and other data if provided by State)
- 50% Exclusions
 - Remaining U.S. Forest Service and DOD lands
- 0% Exclusions
 - Remaining Bureau of Land Management lands

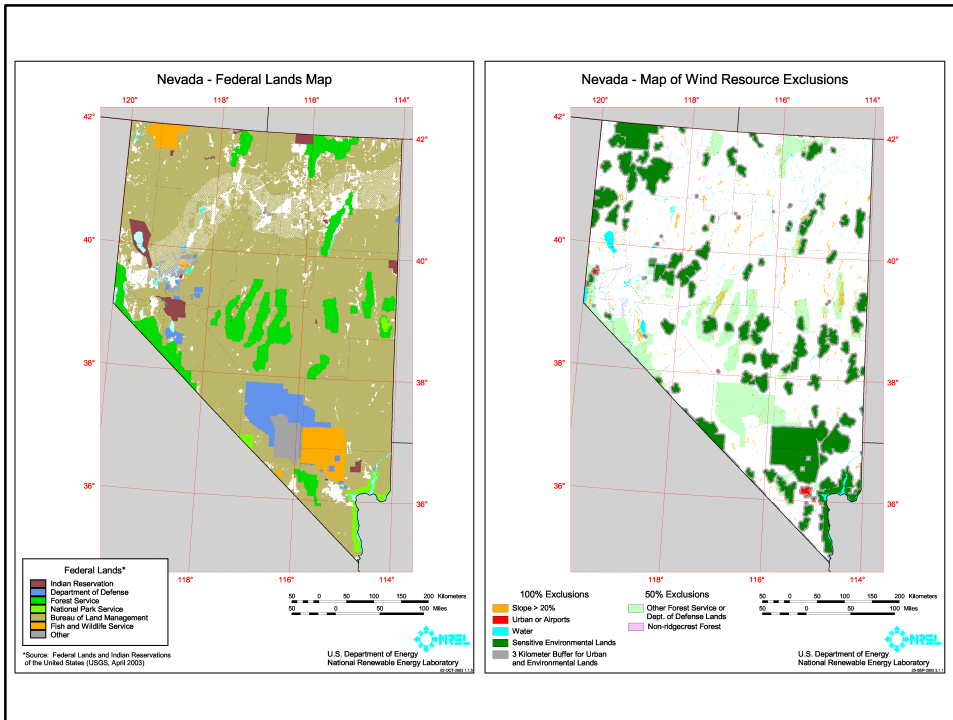


Land-Use Exclusions

- 100% Exclusions
 - Urban areas and airports
 - Wetlands
 - Water bodies (includes seasonal or dry lakes)
- 50% Exclusions
 - Non ridge crest forest
- 0% Exclusions
 - Ridge crest forest
 - Agriculture and range lands

Additional Windy Land Factors

- Slope Exclusions
 - Slopes greater than 20% excluded
- 3 km buffer around airports and the 100% exclusion areas, except for water bodies
- Windy grid cell contiguity/density factor
- New methodology slightly less restrictive than used in 1991-93
- Distance from transmission lines not included in windy land calculations
- Windy land → electric potential
 - Direct conversion from sq. km to potential installed capacity- 5 MW per km² of available windy land



Nevada Wind Electric Potential (Installed Capacity)

- | | Total before exclusions | Developable |
|---|-------------------------|-------------|
| • Class 3 + | 49,260 MW | 23,740 MW |
| • Class 4 + | 15,850 MW | 6,630 MW |
| • Class 5 + | 6,770 MW | 2,400 MW |
| • Class 6 + | 3,390 MW | 1,030 MW |
| • 52% of the raw Class 3+ lands excluded | | |
| • 58% of the raw Class 4+ lands excluded | | |
| • 1993 Nevada potential for Class 4+ was 25,480 MW | | |
| – 1993 based on 7 MW per sq. km versus 5 MW in 2003 | | |
| – 1993 was 3,640 sq. km windy land versus 1,326 sq km in 2003 | | |



Status of Hawaii Validation

- Validation consultants under contract to begin work
 - Criteria: Unique wind data sets and previous experience in Hawaii wind assessment
- Validators
 - NREL
 - GEC
 - John Wade
 - Rich Simon
- Data sets for evaluation being identified and obtained
 - NREL in-house data
 - Data from sources in Hawaii
 - Data from other sources including proprietary data



Tentative Schedule for Hawaii Validation

- Feb 15 - Data sets identified and obtained
 - Send data or comments to: **dennis_elliott@nrel.gov**
 - Or call **(303) 384-6935**
- Mar 15 - Data processed and analyzed
- Apr 15 – Validation completed
- May 15 – Final maps completed
- June 1 – Wind electric potential calculated